Nicholas Hartmann
611 N. Broadway, Suite 509
Milwaukee, WI 53202

(414) 271-4890
fax: (414) 271-4892
nh@nhartmann.com

Technical and scientific translator – German, French & Italian into English

Declaration

I, Nicholas Hartmann, translator, having an office at 611 N. Broadway, Suite 509, Milwaukee, WI, 53202, declare that I am well acquainted with the English and German languages and certified by the American Translators Association in translation from German to English, and that the appended document is a true and faithful translation of:

International Patent Application PCT/EP2005/013261 entitled

"MiniLifter"

[Mini-fan]

All statements made herein are to my own knowledge true, and all statements made on information and belief are believed to be true; and further, these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the document.

Date June 26, 2016

Nicholas Hartmann

MINI-FAN

The invention relates to a mini-fan. Such fans are also referred to as miniature or subminiature fans.

Sensor fans are used for air measurement, e.g. for air-conditioning systems in motor vehicles. These fans have, for example, an outside diameter of 30 mm, i.e. these are what is referred to in technical jargon as mini-fans.

Mini-fans of this kind also serve to cool processors in computers, for equipment cooling in small equipment, etc., and their dimensions are very small. For example:

fans of the ebm-papst 250 series have dimensions of 8 x 25 x 25 mm;

those of the ebm-papst 400F series have dimensions of 10 x 40 x 40 mm;

those of the ebm-papst 400 series have dimensions of 20 x 40 x 40 mm; and

fans of the ebm-papst 600 series have dimensions of 25 x 60 x 60 mm.

The power consumption of such fans is 0.4-0.6 W for the 250 series, 0.7 to 0.9 W for the 400F series, and 0.9-3.4 W for the 400 and 600 series. Their weight is, for example, approximately 5 g for the 250 series, between 17 g and 27 g for the 400/400F series, and approximately 85 g for the 600 series.

In fans of this miniature size, which must be very inexpensive, it is important to make the assembly thereof extremely simple, so that they can be manufactured with a high degree of automation and so that such fans exhibit uniform quality and low noise.

A further complicating factor with such extremely small fans is that their components, entirely analogously to those of a mechanical clock mechanism, are very delicate and therefore not very robust. The rotor shaft, for example, is often only as thick as a knitting needle and therefore can easily be bent if handled carelessly, rendering the fan unusable. The same applies to pole pieces.

It is therefore an object of the invention to make available a novel mini-fan.

According to the invention, this object is achieved by the subject matter of Claim 1. Because a portion of the coil former is implemented as a carrier on which electrical elements of the motor can be arranged, e.g. components, connector elements, or the like, a very simple and compact design is obtained; this is extremely important specifically for mini-fans. Another advantage that results is that of a low-vibration configuration, so that such a mini-fan consequently operates in low-noise fashion.

Further details and advantageous refinements of the invention are evident from the exemplifying embodiment, in no way to be understood as a limitation of the invention, that is described below and depicted in the drawings, and from the dependent claims. In the drawings:

FIG. 1 is a partially sectioned three-dimensional depiction of a mini-fan according to a preferred exemplifying embodiment of the invention, shown greatly enlarged;

FIG. 2 is a three-dimensional depiction of the fan of FIG. 1, in which the fan is not shown sectioned;

FIG. 3 depicts a contact pin with which the mini-fan can be attached to a circuit board, this contact pin creating both an electrical and an additional mechanical connection between the fan and the circuit board;

FIG. 4 is a section viewed along line IV-IV of FIG. 3;

FIG. 5 is an exploded view of the essential parts of a mini-fan according to the present invention;

FIG. 6 is a three-dimensional depiction of a pole piece;

FIG. 7 is a section viewed along line VII-VII of FIG. 6;

FIG. 8 is a section through a claw pole stator that uses pole pieces as shown in FIG. 6;

FIG. 9 is a three-dimensional depiction, from above, of the internal stator shown in section in FIG. 8;

FIG. 10 is a three-dimensional plan view, from below, of the internal stator of FIG. 9;

FIG. 11 is a schematic depiction of a populating method that can be used in preferred fashion in the context of the invention;

FIG. 12 is a three-dimensional depiction of a first variant;

FIG. 13 is a plan view, from above, of the fan of FIG. 12; and

FIG. 14 is a three-dimensional depiction of a second variant.

FIG. 1 shows a mini-fan 10 that, in practice, can usually have a diameter of 30 to 35 mm but is shown greatly enlarged for illustrative purposes. It has an external housing 12 made of an insulating plastic, and this housing has at the top an air inlet opening 14 and on the sides air outlet openings 16, of which only the rear one is visible in FIG. 1.

Proceeding from air inlet opening 14, housing 12 widens via an annular portion 18 into a cylindrical portion 20.

A circuit board 22 rests on annular portion 18, and a sealing ring 24 made of sponge rubber is mounted on that board in the manner depicted.

Circuit board 22 is substantially round and has at its center a crosspiece 26, of which only the rear half is visible in FIG. 1 and on which is arranged an NTC resistor 28 that serves as a temperature sensor for air that flows in from above through opening 14 in the direction of arrows 30, 32, and flows out through lateral opening 16.

NTC resistor 28 (using SMD design) is connected via conductors 34 to contact pins 36, 38 that are arranged in insulated fashion, as depicted, in cylindrical part 20 of external housing 12. These metal pins 36, 38 each have at the bottom a contacting foot 36', 38', respectively, each of which has two resilient elements 40, 42 that are depicted in FIG. 4. Contacting feet 36' and 38' are inserted, as shown by FIGS. 3 and 4 respectively, into an opening 44 of a circuit board 46. This opening 44 is connected to a metal layer 47 that extends through opening 44 and is connected to a conductor 48 of circuit board 46. Contacting feet 36', 38' thus create electrical connections from circuit board 46 to fan 10 and its temperature sensor 28. Especially in the case of very small fans, it is usual for the components for electronic commutation to be located not in fan 10 itself but rather on the associated circuit board 46. It is also possible within the scope of the invention, however, to arrange these components in fan 10 itself.

Cylindrical part 20 of external housing 12 is closed off at the bottom by a carrier 50 at whose center is arranged a metal bushing 52. The latter is surrounded by a cylindrical portion 54 that is integral with circuit plate 50 and transitions at its upper end into an annular disk 56 that, together with parts 50 and 54, constitutes a coil former for a stator winding 58. Circuit plate 50 has on its outer rim notches 51 through which contact pins 36 and 38, as well as other contact pins 53, project.

Located inside bushing 52 is a sintered bearing (not depicted) for shaft 60 of external rotor 62 of a motor 61. Rotor 62 has a supporting part 64 made of plastic that has at its center a hub 66 into which the upper end of shaft 60 is injection-embedded, said end having a knurled portion 68 for better anchoring. External rotor 62 has approximately the shape of an upside-down bowl, and has at its periphery a rim portion 70 that extends approximately parallel to shaft 60.

As depicted, a permanent magnet 72 is directly injection-embedded into this rim portion 70 using the two-component injection method. Magnet 72 is made of hard ferrites in a plastic matrix, and this plastic with its hard-ferrite particles 74 (which of course can be depicted only schematically) can therefore be injection-embedded, for example as a ring, into carrier part 64, in which context the interfaces, which are symbolized by dot-dash lines, are intimately joined by contact melting of the plastics.

Subsequent to the injection-embedding of magnet ring 72, the latter is radially magnetized in a suitable apparatus, as symbolically depicted in FIG. 1 in the usual way by the letters N (North pole) and S (South pole).

Radially extending fan blades 80 are implemented integrally with carrier part 64, i.e. the fan is preferably a radial one.

A great advantage of the invention is that with this manufacturing method, external rotor 62 is already largely balanced once the plastics have been injected, so that only minor balancing work, at most, is necessary. An economy is also achieved in terms of assembly, since it is just such extremely small parts that are difficult to handle and assemble, and errors might therefore easily occur during assembly. The invention eliminates waste, since rotor 62 with its rotor magnet is available during assembly as a completed and tested part that simply needs to be installed in the bearing, this usually being done by inserting shaft 60 into the bearing.

In the fan according to FIG. 1, free end 82 of shaft 60

constitutes an axial bearing together with portion 83, located there opposite that end 82, of carrier 50. End 82 of shaft 60 is thereby pressed downward against portion 83; this is achieved by the fact that magnet ring 72 is offset in an axial direction relative to cylindrical portions 84, 86 (depicted in FIG. 1) of a claw pole part 88. Magnet ring 72 is thereby pulled downward by an axial force F.

Portion 83 is formed by the fact that during manufacture, material of carrier 50 travels through openings 85 of bushing 52 into the latter's interior (cf. FIG. 10).

As FIGS. 5 to 10 show particularly clearly, fan 10 has an internal stator 90 that is implemented as a claw-pole design.

Coil former 57, already described, has wound onto it a coil 58 that usually has two separate windings that are wound in bifilar fashion, for example a drive winding having two terminals 92, 94, and a sensor winding having two terminals 96, 98 (cf. FIG. 5 and FIG. 9). The use of a sensor coil and a drive coil is known in this context (cf. EP 1 104 950 A2 (EP226 = EP-3046)).
If a Hall sensor is used, operation is also possible, for example, using two drive coils, in accordance with WO 00/35074
(PCT221 = PCT-3044).

As depicted, terminals 92 to 98 are guided to lateral contacts that are embedded into circuit plate 50 (preferably using the MID method) and that are each connected to associated contact pins 53 that extend through grooves 51 and thereby create an electrical connection to metal coatings 100 provided there.

Two barbs 102, 104 are shaped onto the bottom of carrier 50 (cf. FIGS. 5 and 10; these barbs are not depicted in FIG. 1). The mini-fan is releasably latched onto circuit board 46 (FIG. 3) with these barbs, and contact pins 36', 38', 53 create the electrical connection to conductors 48 of circuit board 46. After coil 58 has been wound onto it, upper pole piece 88 is mounted from above onto coil former 57. Said piece has a central opening 106 with which it is pressed onto bushing 52. As shown in FIGS. 6 to 8, upper pole piece 88, and likewise lower pole piece 110 that is identical to it, has on its outer side 112 a plastic coating that
a) covers the outer side of claw poles 84, 86 (cf. FIG. 9); and
b) extends, approximately in the shape of annulus segments 114, 116, into gaps between the adjacent claw poles 84, 86 (cf. FIG. 6).

Each of these annulus segments 114, 116 is equipped with a respective projection 118, 120 (FIG. 7) which serves to weld that annulus segment to the adjacent side part 50 or 56 of coil former

57. This is accomplished preferably by laser welding, the relevant projection forming a nondetachable connection to the associated side wall 50 or 56 of coil former 57, as depicted in FIG. 8 for side wall (carrier) 50.

Lower pole piece 110 is, in the same fashion, pressed with its central opening onto bushing 52 and then welded to carrier 50.

As FIG. 9 and FIG. 10 show particularly well, carrier 50 has for this two orifices 122, 124 through which the claw poles of pole piece 110 are inserted. The two pole pieces 88 and 110, as shown in FIGS. 9 and 10, are offset 90° (mechanical) from one another, and consequently engage interdigitally into one another. Each of the claw poles has five radially extending recesses 126 that are depicted in FIG. 6, and plastic 112 is anchored into these recesses 126 and fills them up. This decreases magnetostrictive noise as well as air turbulence. Recesses 126 serve primarily to reduce eddy-current losses.

FIG. 11 shows a preferred method for populating carrier (circuit plate) 50 in such mini-fans. This method exploits the fact that this carrier 50 can already be made, by injection molding, into any desired shape.

In FIG. 11A), adhesive 130 is dispensed at specific locations onto carrier 50 which, as depicted, can have any shape.

In FIG. 11B), corresponding SMD components 132 are mounted onto these adhesive dots 130.

In FIG. 11C), adhesive dots 130 are allowed to cure in an appropriate oven.

In FIG. 11D), the component is coated with conductive strips 134; and

in FIG. 11E), those strips 134 are cured using UV light. Carrier 50 is then populated and ready to use.

The term "molded interconnected device" is also applied to this manufacturing method.

By means of this manufacturing method, the connections necessary for the electronics are applied directly onto coil former 57. The injection-molded parts manufactured in this fashion are immediately ready for further processing. Holes or adaptations no longer need to be incorporated after the fact, but instead are integrated directly into the components by way of the injection-molding manufacturing molds. In addition to the quality advantages and the reduced manufacturing complexity, this method also offers positive environmental features by omitting lead-containing solder and eliminating circuit boards made of materials that usually cannot be recycled, and reliability is enhanced at low cost.

FIGS. 12 and 13 show a variant in which a special circuit board is not necessary. Instead, two conductors 140, 142 are here incorporated, using a hot-stamping method, into upper side 144 of fan housing 146. Conductor 140 is connected at its left end to a contact pin 148 and at its right end to an NTC resistor 28'. Conductor 142 is likewise connected at its right end to a contact pin 150 and at its left end to NTC resistor 28'.

Be it noted that in FIGS. 12 and 13, parts that have the same function as in the previous Figures are also labeled with the same reference characters and are not described again.

Provided around air inlet opening 14' in FIGS. 12 and 13 is a projecting collar 152 that protects NTC resistor 28' from mechanical damage. A strut 152, on which NTC resistor 28' and conductors 140, 142 are located, is implemented as part of housing 146.

Contact pins 148, 150 extend through housing 146 and project downward out of it.

FIG. 13 shows the fan of FIG. 12 in a plan view from above. The elimination of a special circuit board for NTC resistor 28' results in substantial simplification and cost reduction, while complete functionality is maintained.

FIG. 14 shows a variant. In this, a respective flexible permanent magnet 226 and 228 is arranged at each of two points 222, 224, located opposite one another, in a cylindrical portion 220 of lower housing part 212. These magnets are in the form of flexible plastic parts in which hard-ferrite particles are present, and they are also referred to as "rubber magnets."

Prior to the manufacture of housing part 212, these magnets are placed into an injection mold and retained there at the points labeled 228 in FIG. 14. The relevant magnets can also be curved into a desired shape in the context of this operation, if that proves useful during manufacture.

The magnets are then injection-embedded in the plastic of the lower housing part so that they are fixedly anchored in that housing part and cannot fall out.

These magnets 226, 228 serve to rotate rotor 62, prior to starting, into a position from which it can easily start.

The invention thus yields a mini-fan having a very compact and robust internal stator 90. The reader must bear in mind in this context that when the outside diameter of mini-fan 10 in FIG. 2 has a value of, for example, 35 mm, the diameter labeled D in FIG. 8 is only approx. 20 mm, i.e. these are extremely small parts that must be manufactured

a) at low cost; and

b) with great precision.

It must further be kept in mind that many claw poles can have, for magnetic reasons, shapes that are substantially more complicated than the shape depicted in FIG. 6, which can make manufacturing and processing even more difficult.

Many variants and modifications are of course possible within the scope of the present invention.